STEMscopes NGSS 3D
K-12 SCIENCE

Thermal Energy Transfer

6th Grade Sample Lesson

www.stemscopes.com/science

Scope (Unit) Thermal Energy Transfer

Explore (Lesson) Scientific Investigation - Energy Transfer and Matter

The following pages introduce lesson resources that guide you through the STEMscopes NGSS 6th grade lesson. This sample lesson does not include all the elements and features of our digital and print science curriculum.

Resource List:

The following resources, as well as additional Scope resources not listed, can be found in the digital curriculum *6th Grade Scope, Thermal Energy Transfer.*

Home

- Standards Alignment
- Sample Lesson Plan
- Teacher Scope Presentation
- Teacher Background
- CCC and SEP Scoring Rubric
- Answer Keys
- Materials List

Engage

- Investigative Phenomena – Introductory activity that facilitates a connection between the content and real-world phenomena and encourages students to ask why or how something happens.
- Graphic Organizer – Students fill this in as they work through the elements of this Scope.
- Accessing Prior Knowledge – A brief probing activity to gauge students' prior knowledge before engaging in the inquiry process.
- Hook – An engaging activity that includes instructor preparation, supplemental resources, and ready-made handouts for students.

Explore

- Explore 1: Activity
- Explore 2: Scientific Investigation – This lesson sample.
- Explore 3: Scientific Investigation
- Explore 4: Inquiry Investigation

Explain

- Picture Vocabulary – Key terms explained through pictures and by definition.
- Linking Literacy – Strategies to help students comprehend difficult informational text.
- STEMscopedia – Reference materials that include parent connections, career connections, technology, and science news.
- Communicate Science – A class activity in which students use different forms of communication to discuss scientific topics connected to the content of this Scope.
- Science Rock - Science Rock – A musical/video software platform where students can sing and learn from standards-based science songs.
- Concept Review Game – An interactive game that helps students review important concepts.
- Content Connections Video – A short video that supports student understanding of the content.

Elaborate

- Math Connections
- Reading Science
- Career Connections
- Scientist Spotlight
- PhET: Simulation Practice
- SEP Simulations

Evaluate

- Claim-Evidence-Reasoning
- Open-Ended Response Assessment
- Multiple Choice Assessment

Intervention

- Guided Practice
- Independent Practice
- Concept Attainment Quiz

Acceleration

- Extensions
- Science Art
- Books on Topic

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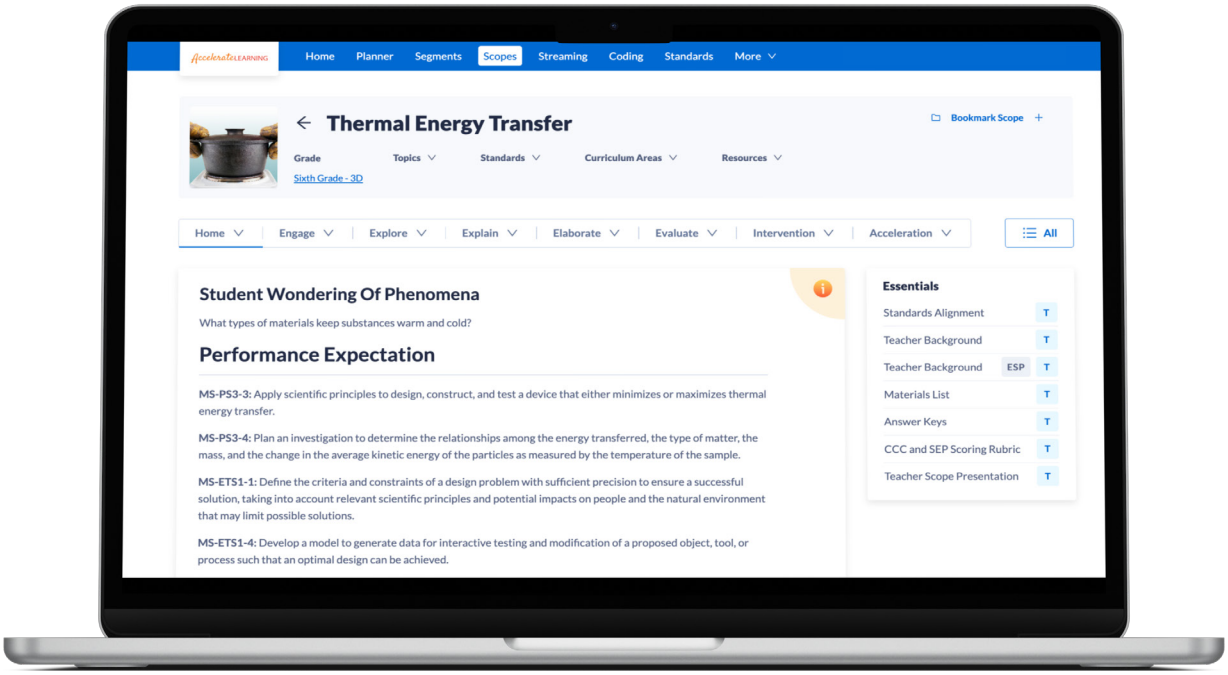
Claim-Evidence-Reasoning, Page 25

Scope (Unit) Overview

Scope (Unit) Thermal Energy Transfer



Student Wondering of Phenomena

What types of materials keep substances warm and cold?

Performance Expectations

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-4: Develop a model to generate data for interactive testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Scope (Unit) Overview

Scope (Unit) Thermal Energy Transfer

Three-Dimensional Focus

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing Explanations and Designing Solutions Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. (MS-PS3-3) Planning and Carrying Out Investigations Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4)	PS3.A: Definitions of Energy Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3, MS-PS3-4) PS3.B: Conversation of Energy and Energy Transfer Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3) ETS1.A: Defining and Delimiting an Engineering Problem The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (MS-ETS1-4) ETS1.B: Developing Possible Solutions A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (MS-ETS1-4)	Energy and Matter The transfer of energy can be tracked as energy flows through a designed or natural system. Scale, Proportion, and Quantity Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Thermal Energy Transfer

Explore 2: Scientific Investigation - Energy Transfer and Matter

Everyday Phenomena

Does the type of material affect how thermal energy is transferred?

Description

Students conduct an investigation to determine the effect of different types of matter on thermal energy transfer by tracking energy flow in a designed system.

Student investigations identify independent/dependent variables and controls, tools needed, measurements needed, and involves gathering and analyzing data.

Materials

Printed Materials

1 Energy Transfer and Matter (per student)

Reusable

1 Cup, metal, OR picture (per class)
1 Cup, plastic, OR picture (per class)
1 Cup, wood, OR picture (per class)
1 Spoon, metal (per group)
1 Spoon, plastic (per group)
1 Spoon, wood (per group)
1 Timing device (per group)
3 Thermometers or temperature probes (per group)
1 Cooler, insulated (per class)

Consumable

3 Ice cubes, equal size (per group)
1 Tape, masking, 30 cm (per group)

Preparation

- Print one Energy Transfer and Matter and one Energy Transfer and Matter CER for each student.
- Ice cubes need to be uniform in size. Keep the ice in the cooler until it is needed by students. Use spoons of the same thickness and material if possible.

Technology Suggestion

Temperature probes may require a data interface to connect to a graphic calculator or computer, so students may need to review how to set up this connection beforehand, as well as find out if any system updates may need to be performed.

Differentiation Points

Group students who need more guided practice together and spend more time with them to monitor their activity. Let other groups work more independently.

STEMcoach in Action

The skills inherent in designing and implementing a scientific investigation are applicable to many situations outside of the science classroom. Skills such as observing, asking questions, collecting and analyzing data, and drawing and communicating reasonable conclusions are important to all individuals. When we say "cultivating scientific investigation" we are describing the practices that help students develop the skills associated with scientific investigation. For more information on Cultivating Scientific Investigations, please click on the provided link.

Site

Procedure and Facilitation Points

1. Show students a plastic cup, a metal cup, and a wooden cup.
    a. Why would you choose one cup over another? Accept all ideas.
    b. Which cup would you want to use if you had to hold an ice-filled cup in your hand for an hour? Accept all ideas.
    c. Why would you choose a certain cup? Accept all ideas.
    d. What type of energy transfer occurs between the ice, cup, and your hand? Conduction
2. Remind student of the vocabulary word energy:
    a. The ability of a system to do work. Energy is required for changes to happen within a system
3. Remind students of the vocabulary word kinetic energy:
    a. Energy of motion
4. Remind students of the vocabulary word temperature:
    a. Average kinetic energy of all the particles in a material; measured by a thermometer in degrees (usually Celsius or Fahrenheit)
5. **(SEP)** Read the research question with the class and show them the materials. Have students determine the independent variables, dependent variables, and the constants.
    a. Question: Does the type of material affect the thermal energy transfer?
    b. Variables:
        i. Independent variable (also known as the manipulated variable): Material of spoon
        ii. Dependent variable (also known as the responding variable): Change in temperature in °C
        iii. Control variable(s) or group (also known as constants): Same-size ice cubes, same thickness of spoon
    c. Hypothesis: If the type of material affects thermal energy transfer, the material used to make eating and cooking utensils could be important to avoid burns or other unpleasant circumstances.

6. Have students conduct the following investigation:
    a. Collect a spoon made of each material (metal, plastic, wood), three thermometers, and three ice cubes of equal size.
    b. Lay the thermometers on a flat surface.
    c. Lay the bowl of each spoon on top of the bulb of a thermometer. Secure each spoon by taping the handle to the table.
    d. Record the temperature reading for each spoon.
    e. Place an ice cube in each spoon. Start the timer.
    f. Take a temperature measurement for each spoon after 1 minute. Record the temperature of each spoon.
    g. Continue collecting and recording temperature measurements each minute for a total of 5 minutes.
    h. Calculate the total change in temperature for each type of material, and then calculate the percentage change in temperature for each.
7. Data Analysis
    a. Have students write a general statement about the results.
        i. What results does the graph show? The metal material had the greatest change in temperature; the wooden material had the least.
8. Conclusion Questions:
    a. Our investigation of the spoons is a simple model for a more complex and wide-reaching idea. What scientific concept did we model? Conduction and thermal transfer between different types of materials.
    b. How did the model track the transfer of energy as it flowed through the system? By taking an initial temperature reading and temperature readings each minute, we were able to track the flow of thermal energy from the spoon to the ice.
        i. Record this example of scale and proportion on the class crosscutting concept chart. Discuss other examples of scale, proportion, and quantity that the students have previously explored. Charts can be found in the teacher toolbox.
    c. What was the magnitude of the effect of each type of material on thermal energy transfer? The magnitude of the effect of each material can be determined by comparing the percentage change in temperature that occurred over 5 minutes. The metal spoon allowed a greater transfer of thermal energy with a ____% change in temperature. The wooden spoon allowed the least transfer of thermal energy with a _____% change in temperature.
    d. How does this model apply to your daily life? Accept all answers. It helps us choose what kind of cup to use for a very hot or cold liquid, when we need to use a potholder to lift a pot or lid, what kind of container to use to keep food hot or cold, or even the surface where we choose to sit on a hot and sunny day!
    e. If this model were to be extended, what applications could it have for developing new products? It could help scientists and engineers determine the best materials to use where very high or very low conductance is required, such as in electronics, computer technology, heating and cooling systems, etc.
9. Have students add to their list of possible tests they can do on their own to further explore this topic. They will use the list to help them plan and conduct their own investigation in Explore 4!
10. Have students go to their Investigative Phenomena Table and write down anything they have learned that helps them answer the Student Wondering of Phenomena question.

Connection to the Investigative Phenomena

Once students have completed the activity, have them refer to the Investigative Phenomena question, anchor their learning, and revise their thinking.

Language Acquisition Strategies

Ticket Out

After students complete the activity, allow them to show you what they have learned by taking part in a Ticket Out. Hand each student an index card. Write the sentence stem on the board and have students write their answers on their index cards. Sentence Stem: "Today I learned..." After students complete this sentence stem, allow them to pair up and discuss their answers with another student. Students turn in their completed tickets as they exit the classroom.

From *Navigating the ELPS in the Science Classroom: Using the Standards to Improve Instruction for English Learners* by John Seidlitz & Jennifer Jordan-Kaszuba (Seidlitz Education)

Math Moment

Sixth Grade Math Moment

This learning task connects to math standard:

6.SP.B.5: Summarize numerical data sets in relation to their context. Have students write a conclusion reporting the following:

- The number of observations
- How the data was collected and the units of measurement
- If the data showed any patterns based on the variables in the investigation

Possible student answer: In our investigation, we took temperature readings in degrees Celsius every minute for five minutes for each of the three spoons. The metal spoon conducted heat the fastest as the temperature dropped the quickest. The plastic spoon was next, and then the wooden spoon conducted heat the slowest.

Seventh Grade Math Moment

This learning task connects to math standard:

MP.2: Reason abstractly and quantitatively.

- Have students think about how the data from this investigation could help manufacturers of different materials.
- Ask the following: How could this knowledge help them save money, design materials for hot or cool weather, and stay safe? Have students create mathematical situations that could potentially be solved with the data they collected.

Student answers will vary.

Eighth Grade Math Moment

NGSS specifies no Common Core Math alignment; however, we suggest extending this learning task by connecting it to math standard:

MP.2: Reason abstractly and quantitatively.

- When creating the graph, remind students to think about how the data is related.

- Ask the following: How would you describe the shape of your data? Does the shape of the data differ for the different materials tested?

Answers will vary based on the data they collected. They should use the terms linear, nonlinear, or no association to describe the data.

Check out this module's Math Connections for further practice!

Explore

Thermal En

Explore Lesson

Name: _____ Date: _____

Energy Transfer and Matter

Question:
Does the type of material affect the thermal energy transfer?

Variables:
Independent variable (also known as the manipulated variable):

Dependent variable (also known as the responding variable):

Control variable(s) or group (also known as constants):

Hypothesis:

Materials:
Reusable
1 Spoon, metal (per group)
1 Spoon, plastic (per group)
1 Spoon, wood (per group)
1 Timing device (per group)
3 Thermometers or temperature probes (per group)

Consumable
3 Ice cubes, equal size (per group)
1 Tape, masking, 30 cm (per group)

Procedure:
1. Collect a spoon made of each material (metal, plastic, wood), three thermometers, and three ice cubes of equal size.
2. Lay the thermometers on a flat surface.
3. Lay the bowl of each spoon on top of the bulb of a thermometer. Secure each spoon by taping the handle to the table.
4. Record the temperature reading for each spoon.
5. Place an ice cube in each spoon. Start the timer.
6. Take a temperature measurement for each spoon after 1 minute. Record the temperature of each spoon.
7. Continue collecting and recording temperature measurements each minute for a total of 5 minutes.
8. Calculate the total change in temperature for each type of material, and then calculate the percentage change in temperature for each.

Explore

Data:

Thermal Energy Transfer and Materials Temperature ℃								
Material	**Initial**	**1 min.**	**2 min.**	**3 min.**	**4 min.**	**5 min.**	**Total Change**	**% Change**
Metal								
Plastic								
Wood								

Make a graph based upon the data.

Thermal Energy Transfer and Materials

Data Analysis:

1. What results does the graph show?

Explore

Conclusion Questions:

1. Our investigation of the spoons is a simple model for a more complex and wide-reaching idea. What scientific concept did we model?

2. How did the model track the transfer of energy as it flowed through the system?

3. What was the magnitude of the effect of each type of material on thermal energy transfer?

4. How does this model apply to your daily life?

5. If this model were to be extended, what applications could it have for developing new products?

Explore

Name: _____ Date: _____

Energy Transfer and Matter

Question:
Does the type of material affect the thermal energy transfer?

Variables:
Independent variable (also known as the manipulated variable):
Material of spoon

Dependent variable (also known as the responding variable):
Change in temperature in ℃

Control variable(s) or group (also known as constants):
Same-size ice cubes, same thickness of spoon

Hypothesis:
If the type of material affects thermal energy transfer, the material used to make eating and cooking utensils could be important to avoid burns or other unpleasant circumstances.

Materials:
Reusable
1 Spoon, metal (per group)
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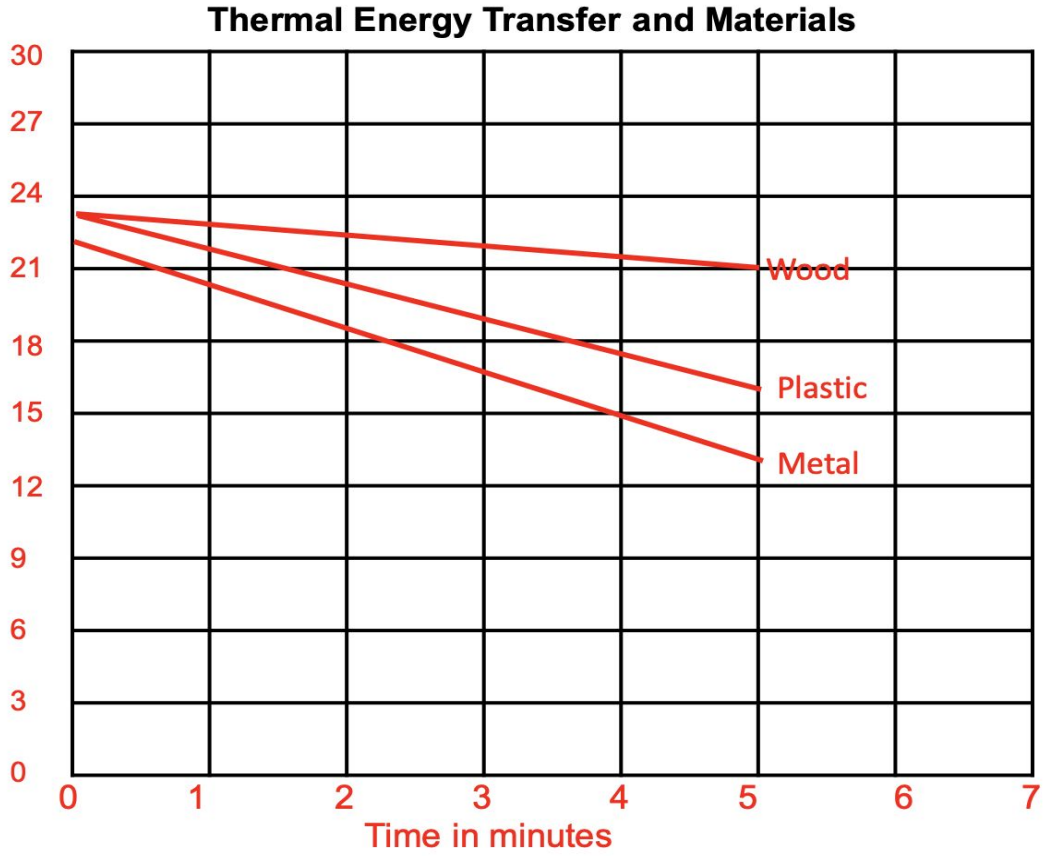
Explore

Data:

Thermal Energy Transfer and Materials Temperature ℃								
Material	**Initial**	**1 min.**	**2 min.**	**3 min.**	**4 min.**	**5 min.**	**Total Change**	**% Change**
Metal	22	18	16	15	14	13	9	40%
Plastic	23	21	20	18	17	16	7	30%
Wood	23	22	22	21	21	21	2	9%

Make a graph based upon the data.



Data Analysis:

1. What results does the graph show? The metal material had the greatest change in temperature; the wooden material had the least.

Explore

Conclusion Questions:

1. Our investigation of the spoons is a simple model for a more complex and wide-reaching idea. What scientific concept did we model? Conduction and thermal transfer between different types of materials

2. How did the model track the transfer of energy as it flowed through the system? By taking an initial temperature reading and temperature readings each minute, we were able to track the flow of thermal energy from the spoon to the ice.

3. What was the magnitude of the effect of each type of material on thermal energy transfer? The magnitude of the effect of each material can be determined by comparing the percentage change in temperature that occurred over 5 minutes. The metal spoon allowed a greater transfer of thermal energy with a _____% change in temperature. The wooden spoon allowed the least transfer of thermal energy with a _____% change in temperature.

4. How does this model apply to your daily life? Accept all answers. It helps us choose what kind of cup to use for a very hot or cold liquid, when we need to use a potholder to lift a pot or lid, what kind of container to use to keep food hot or cold, or even the surface where we choose to sit on a hot and sunny day!

5. If this model were to be extended, what applications could it have for developing new products? It could help scientists and engineers determine the best materials to use where very high or very low conductance is required, such as in electronics, computer technology, heating and cooling systems, etc.

Picture Vocabulary

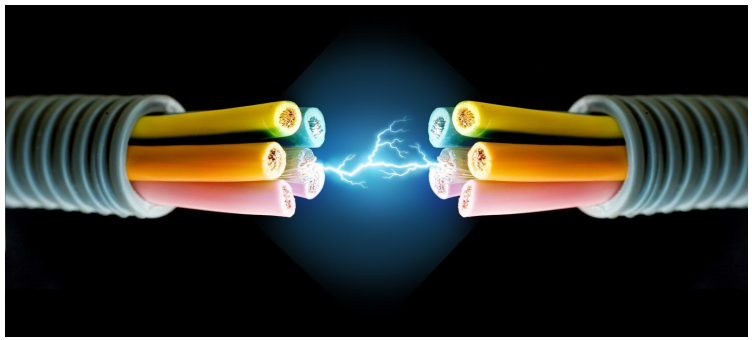
Thermal Energy Transfer

Picture Vocabulary

Conduction

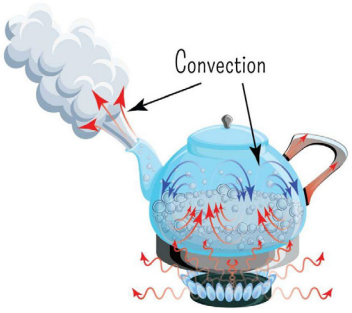
Transfer of thermal energy that occurs in solids, liquids, and gases when two substances of different temperatures touch

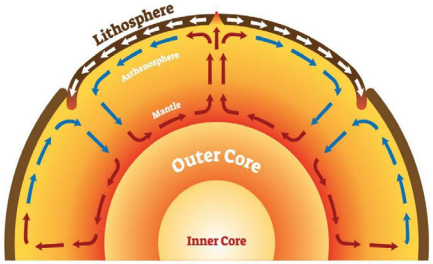
Conductor



A substance that allows the flow of electrical charge or transfers thermal energy through matter

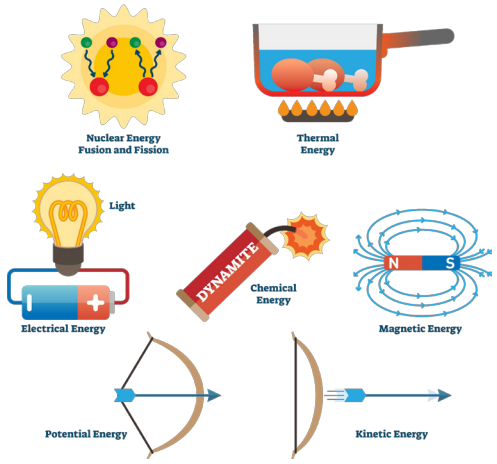
Convection





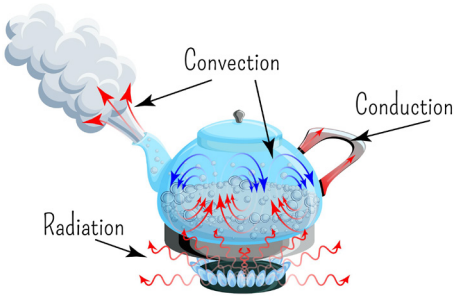
Heat transfer caused by the rising of hotter, less dense fluids and the falling of cooler, denser fluids

Energy



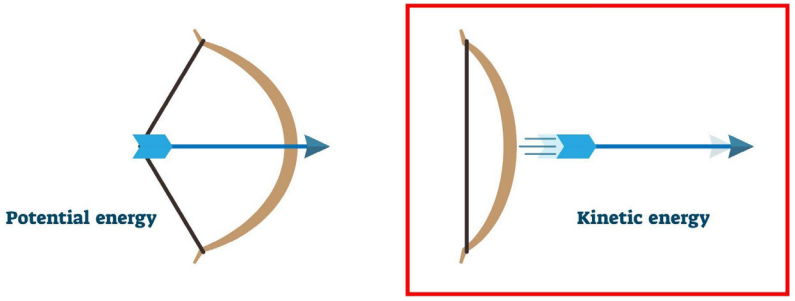
The ability of a system to do work; required for changes to happen within a system

Heat Transfer



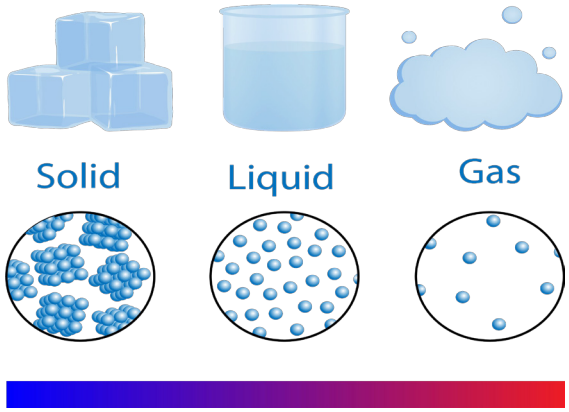
The thermal energy exchange between two objects of different temperatures; energy moves in a predictable pattern from warmer sites to cooler sites until all sites have reached the same temperature

Kinetic Energy



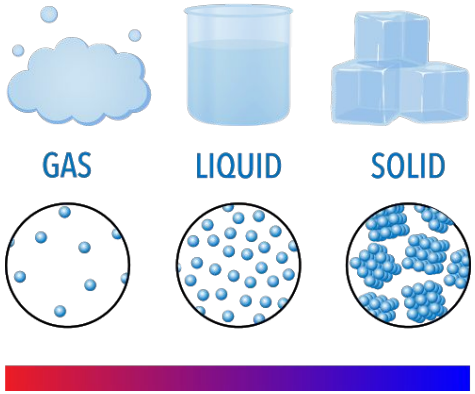
Energy of motion

Matter



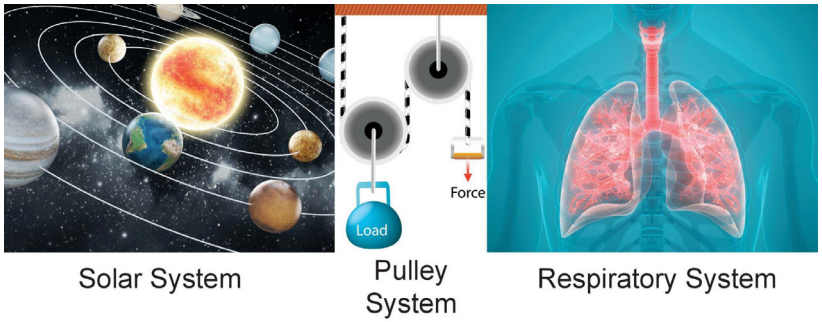
Anything that has volume and mass

States of Matter



Distinct forms of matter known in everyday experience: solid, liquid, and gas; also referred to as phases

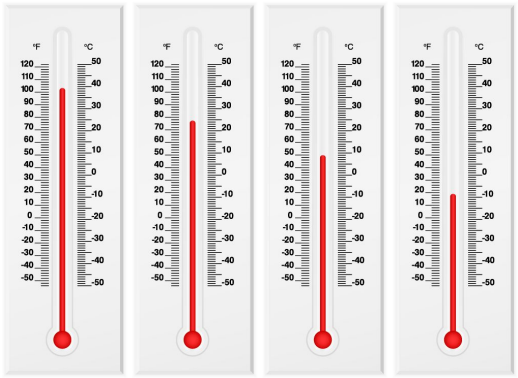
System



Solar System | Pulley System | Respiratory System

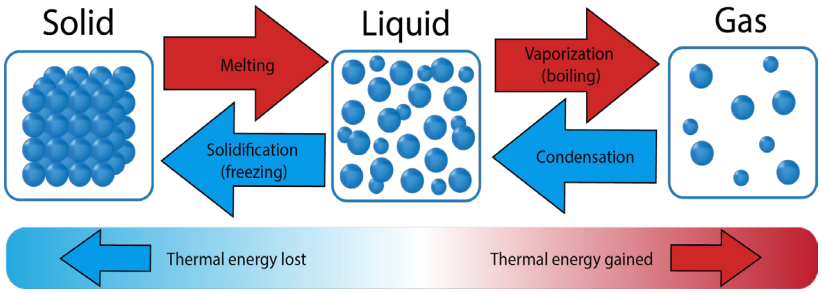
A group of interacting, interrelated, or interdependent elements forming a complex whole

Temperature



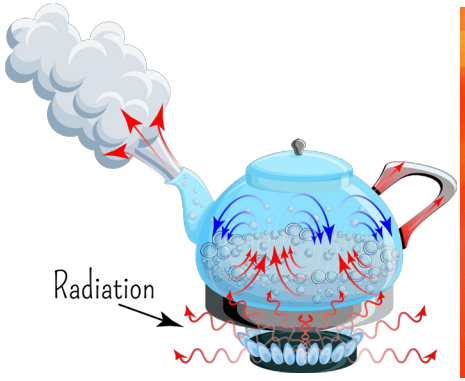
Average kinetic energy of all the particles in a material; measured by a thermometer in degrees (usually degrees Celsius or degrees Fahrenheit)

Thermal Energy



The total kinetic (motion) energy of the tiny particles that make up matter; the faster the particles move, the warmer the matter becomes

Radiation



The transfer of energy by the movement of electromagnetic waves or subatomic particles

Math Connections

Math Connections

Name: _____ Date: _____

Energy Transfer Optimization

Thermal energy can transfer within a system by means of conduction, convection, and radiation. Thermal energy will continue to move in a predictable pattern from a warmer site to a cooler site in a system until all sites have reached the same temperature.

Types of Thermal Energy Transfer

Type of Transfer	Definition	Example
Conduction	Transfer of thermal energy that occurs in solids, liquids, and gases when two substances of different temperatures touch	• Metal cup containing hot cocoa • Ironing clothes
Convection	Transfer of thermal energy through circular motion caused by heating and cooling in fluids	• Boiling soup • Lava lamp
Radiation	Transfer of thermal energy by electromagnetic rays	• Energy emitted by a light bulb • Energy from the Sun • Body heat

In the following experiment, a pan of ice was placed on a hot plate set at 100°C. The temperature of the water was recorded every three minutes, as shown in the chart below.

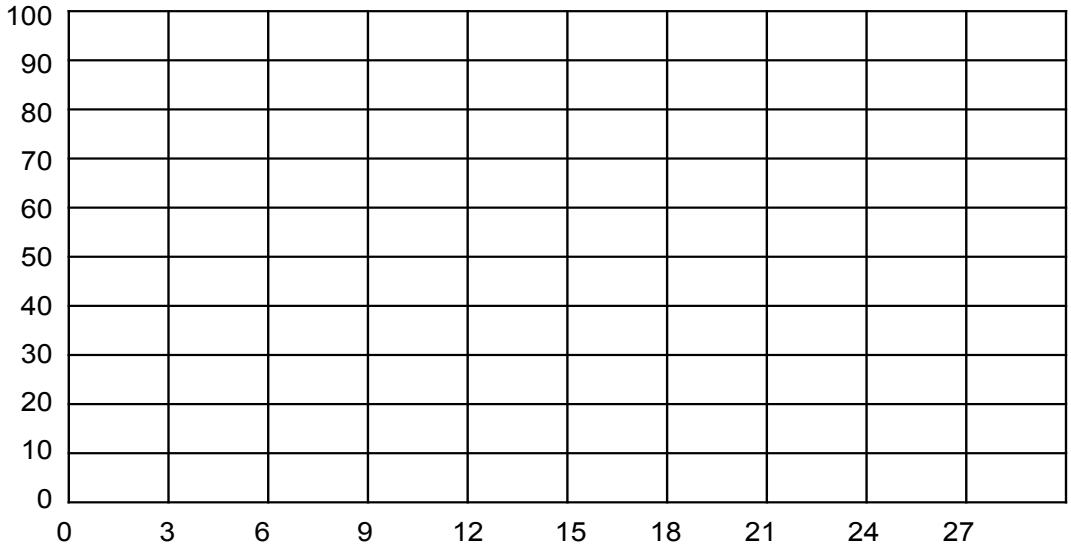
Minutes	0	3	6	9	12	15	18	21	24	27
Temp of Water in °C	0	0	10	25	40	55	70	85	100	100

1. Which type of thermal energy transfer occurred during the experiment?

2. Describe how the energy was transferred during the experiment.

Math Connections

3. Create a scatterplot of the data on the graph below. Label the graph with a title and correct variables on each axis.



4. In the experiment, one variable is independent and one variable is dependent. The independent variable is the one that is changed to cause the other variable. Which variable is the independent variable?

5. The dependent variable is the variable that is measured or observed. This variable is dependent on the changes of the independent variable. Which variable is the dependent variable?

6. What was the rate of change in the temperature of the water per minute during the period from 6 to 24 minutes? The rate of change is also called the slope of the line. It can be calculated by using two points on the line and substituting them in the following formula:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Math Connections

7. When did the water achieve thermal equilibrium? Why did the temperature stop rising?

8. Think about what would happen if the water continued to boil for 45 minutes. Describe the particle movement and what would occur in the water.

Claim-Evidence-Reasoning

Thermal

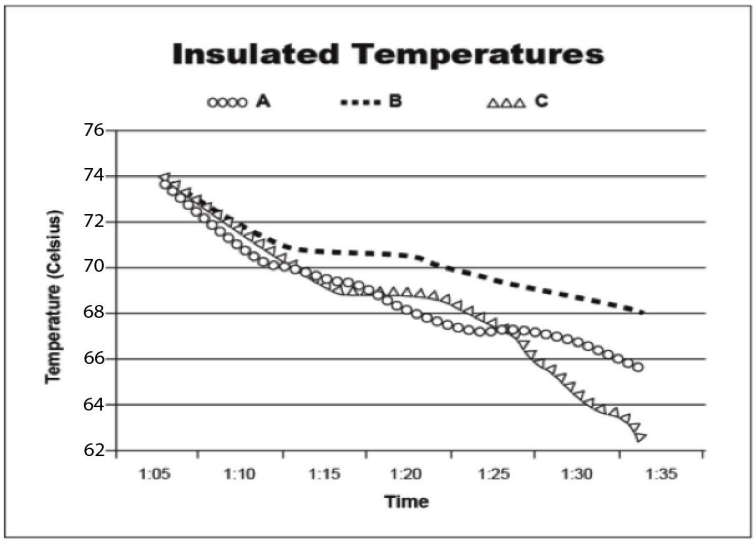
CER Assessment

Name: _____ Date: _____

Scenario

Espresso Coffee House is designing a coffee mug that keeps liquids hot. The researc
tested several different materials for their ability to keep a normal-sized cup of coffee ho
longest amount of time. The testing room temperature is approximately 25°C.

External Data



Prompt

Write a scientific explanation to justify the selection of material, A, B, or C, used to create the cup that would keep the coffee the hottest for the longest period of time.

Claim:

Evidence:

Reasoning:

Peer Evaluation

Peer Name:
Rebuttal:

Claim-Evidence-Reasoning

Rubric for Writing a Scientific Explanation

Points Awarded	2	1	0
Claim	Not applicable.	Answers the question and is accurate based on the data.	No claim or does not answer the question.
Evidence	Cites data and patterns within the data, and uses labels accurately.	Cites data from the data source but not within the context of the prompt.	No evidence or cites changes but does not use data from the data source.
Reasoning	Cites the scientifically accurate reason using correct vocabulary and connects this to the claim. Shows accurate understanding of the concept.	Cites a reason but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning or restates the claim but offers no reasoning.
Rebuttal	Rebuttal provides reasons for different data or outliers in the data. Can also provide relevance to the real world or other uses for the findings.	Rebuttal is not connected to the data or is not accurate.	Does not offer a rebuttal.

Thermal Energy Transfer

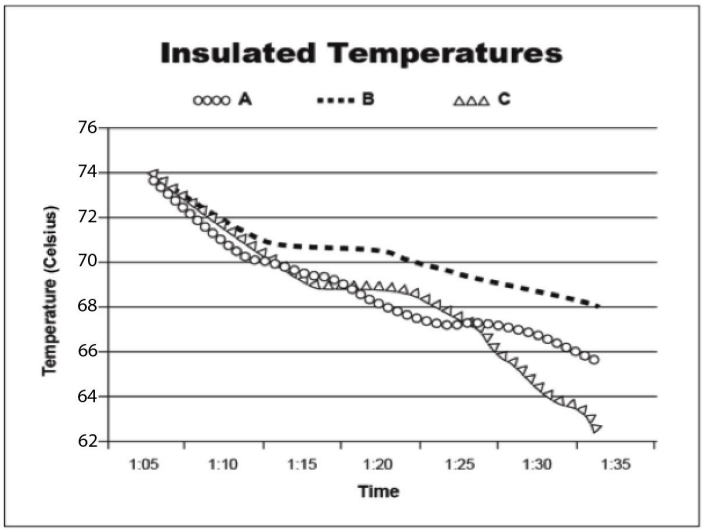
Claim-Evidence-Reasoning

Name: _____ Date: _____

Scenario

Espresso Coffee House is designing a coffee mug that keeps liquids hot. The research department tested several different materials for their ability to keep a normal-sized cup of coffee hot the longest amount of time. The testing room temperature is approximately 25°C.

External Data



Prompt

Write a scientific explanation to justify the selection of material, A, B, or C, used to create the cup that would keep the coffee the hottest for the longest period of time.

Claim: I would use material B to create our cup. It was the best insulator because it kept the coffee the hottest.

Evidence: Material B kept the coffee hotter for the longest period of time. The coffee in the cup made of material C ended up the coolest. The one with material A did pretty well, but the coffee ended up cooler than the one in material B.

Reasoning: Material B is the best insulator. It kept the coffee the hottest for the longest amount of time. Material B was the least effective insulator because the coffee was the coolest.

Peer Evaluation

Peer Name:

Rebuttal:

Claim-Evidence-Reasoning

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